

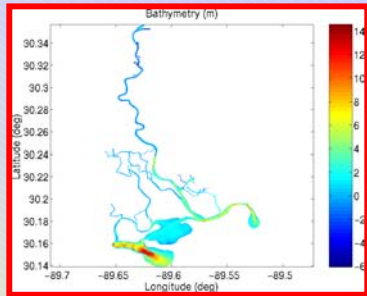
Development of a Forecast Capability for Coastal Embayments of the Mississippi Sound

- Define the forecast system
- Describe circulation model
- Circulation sensitivity studies
 - tide and river flux forcing
 - wind forcing
 - ocean boundary forcing
- Forecasting example

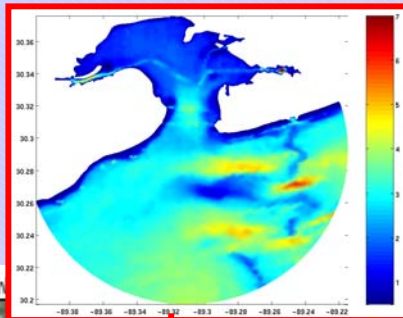


Embayment and River Models of the MS Sound

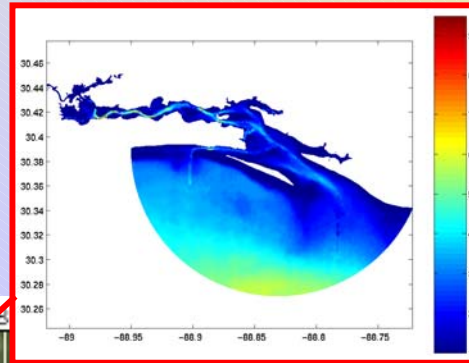
Pearl River Model



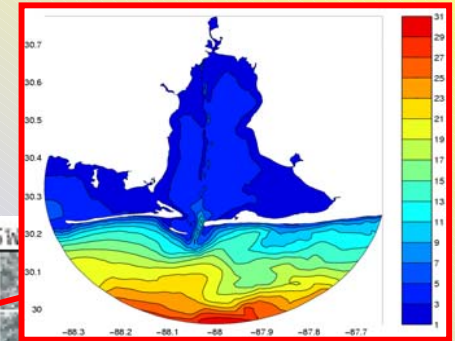
Bay St. Louis Model*



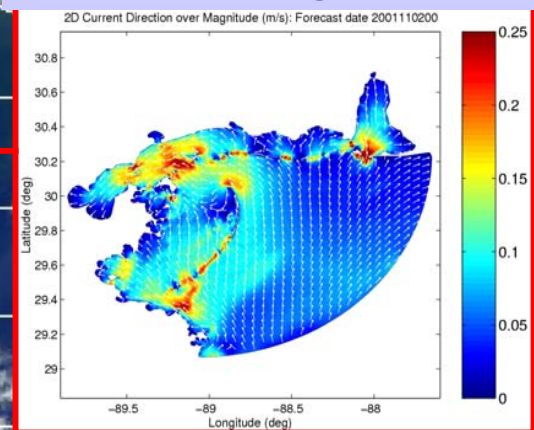
Biloxi Bay Model



Mobile Bay Model



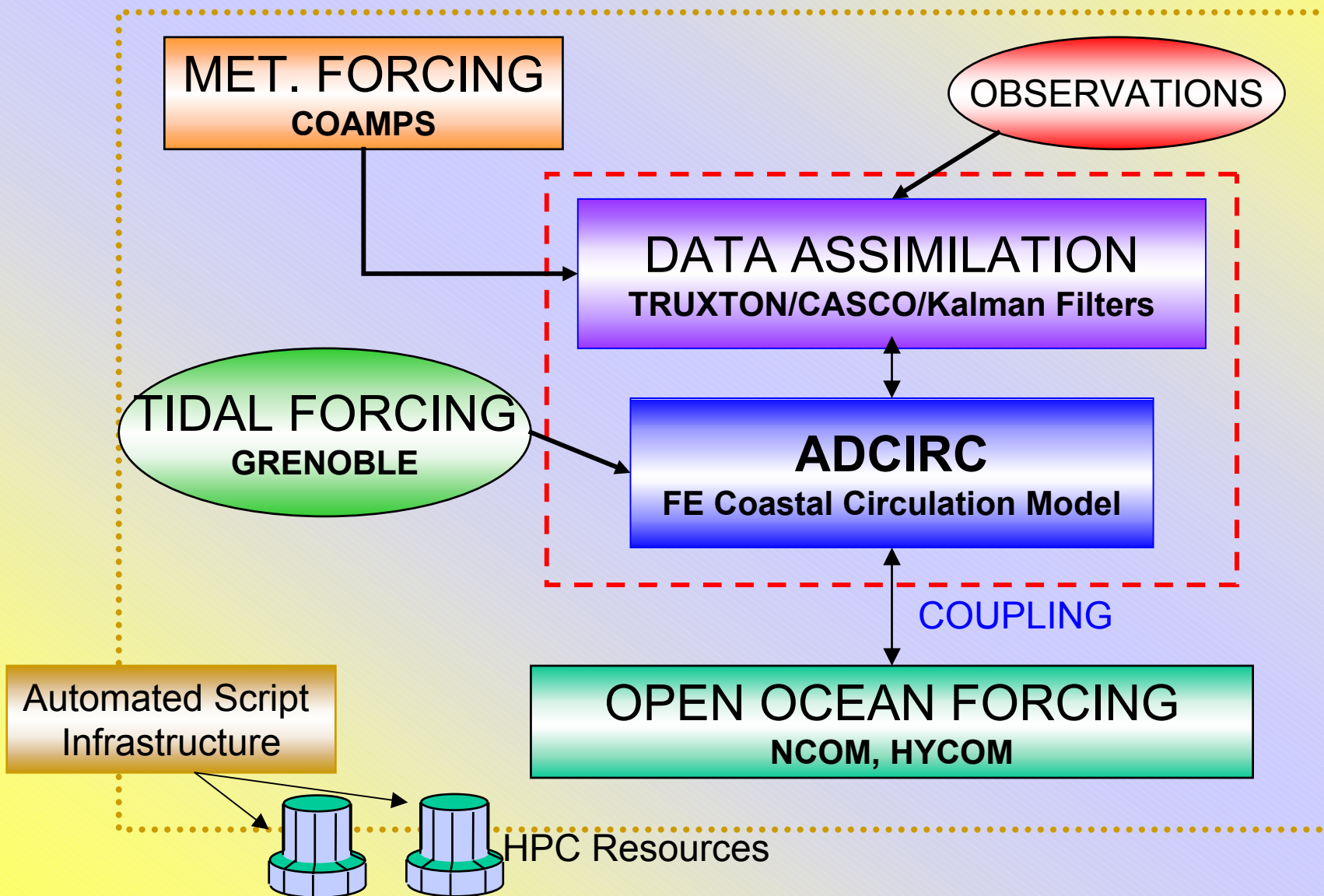
Mississippi Bight Model



*Veeramony, J. and C. A. Blain, in review, 2002. Numerical experiments of bay/shelf exchange, *Continental Shelf Research*.

*Blain, C. A. and J. Veeramony, 2002. The Role of River Discharge and Vertical Mixing Formulation on Computed Circulation in Bay St. Louis, MS, in *Estuarine and Coastal Modeling, Proceedings of the Seventh International Conference*, M. L. Spaulding and K. Bedford, eds., American Society of Civil Engineers, pp.745-764.

FORECAST SYSTEM



ADvanced CIRCulation Model¹

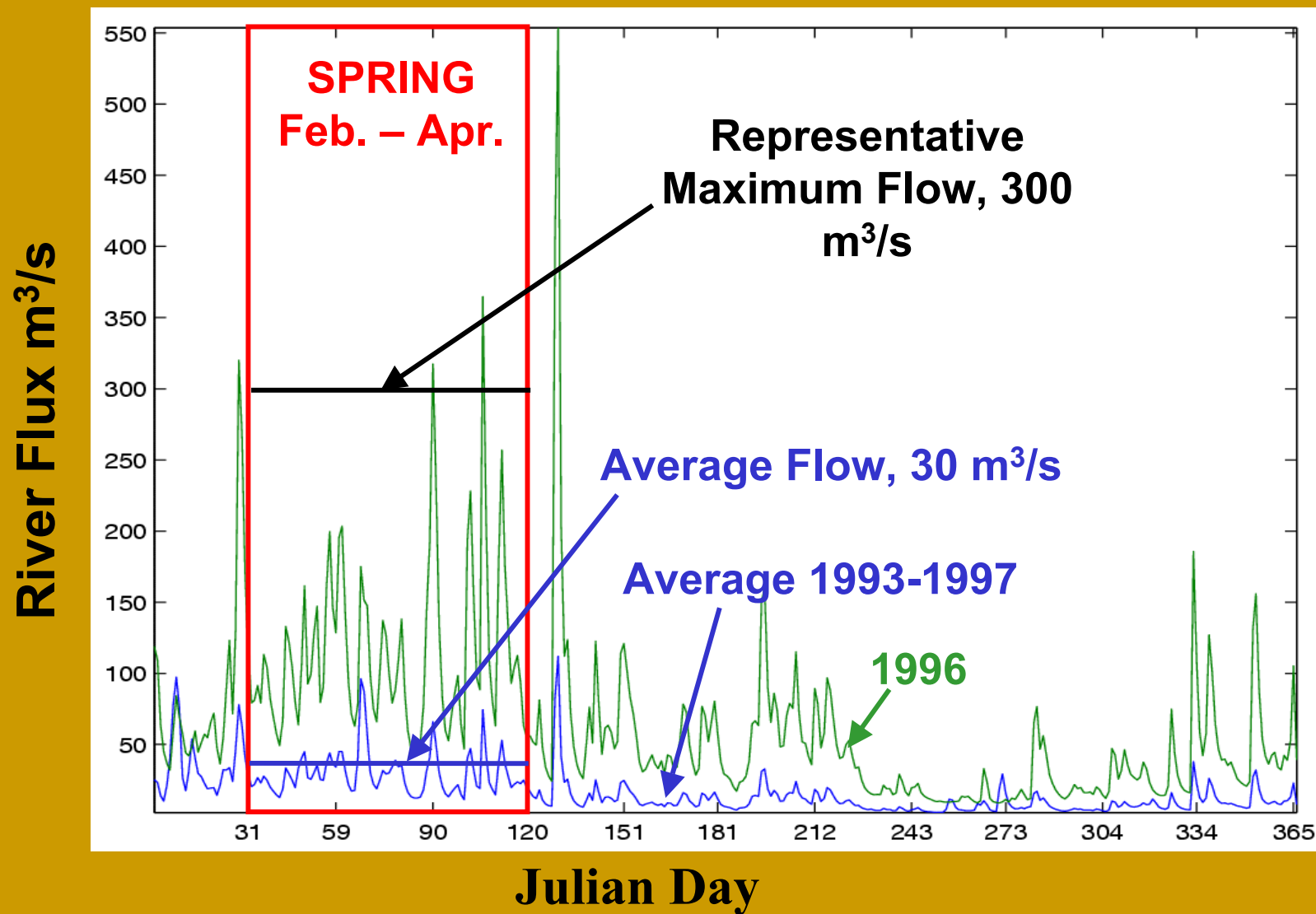
- 2D/3D nonlinear coastal hydrodynamics
 - complete range of dynamical forcing:
tides, wind, waves, rivers, temp, salinity,
offshore models
 - handles shoreline inundation/recession
- Finite element-based discretization
 - new conservative finite element formulation
 - mesh flexibility to:
 - represent coastlines and/or sharp gradient region
 - large domains possible, used to obtain open BCs
- History of real-time forecasting

¹Originally developed by Luettich, Westerink, USACE

SENSITIVITY TO TIDE AND RIVER FORCING

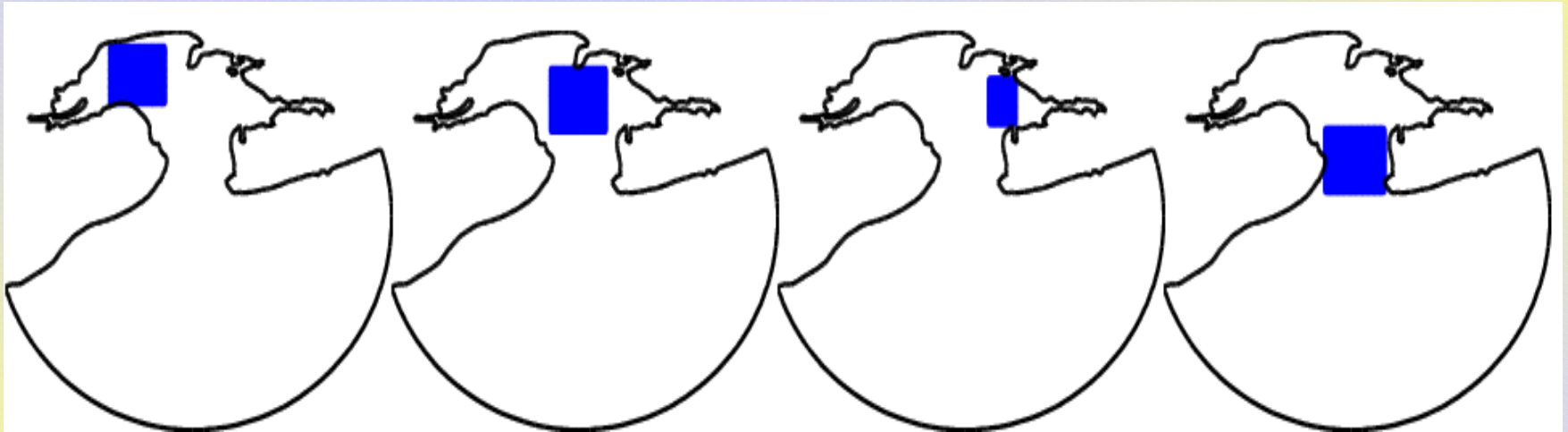
A Model of Bay St. Louis, MS

USGS Stream Gage Data for the Wolfe River



Sensitivity of Bay-Shelf Exchange to Forcing

INITIAL POSITION OF SURFACE DROGUES



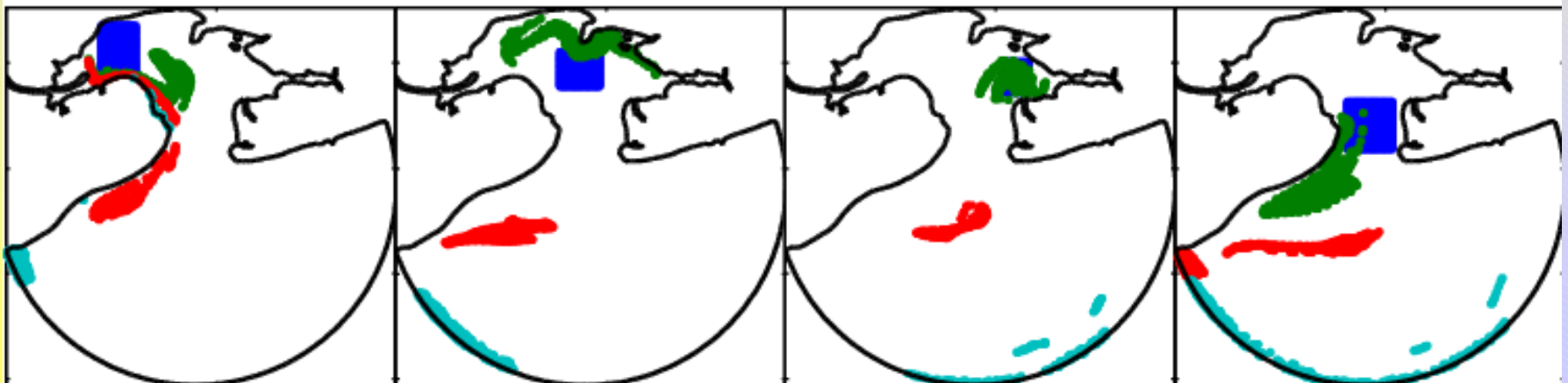
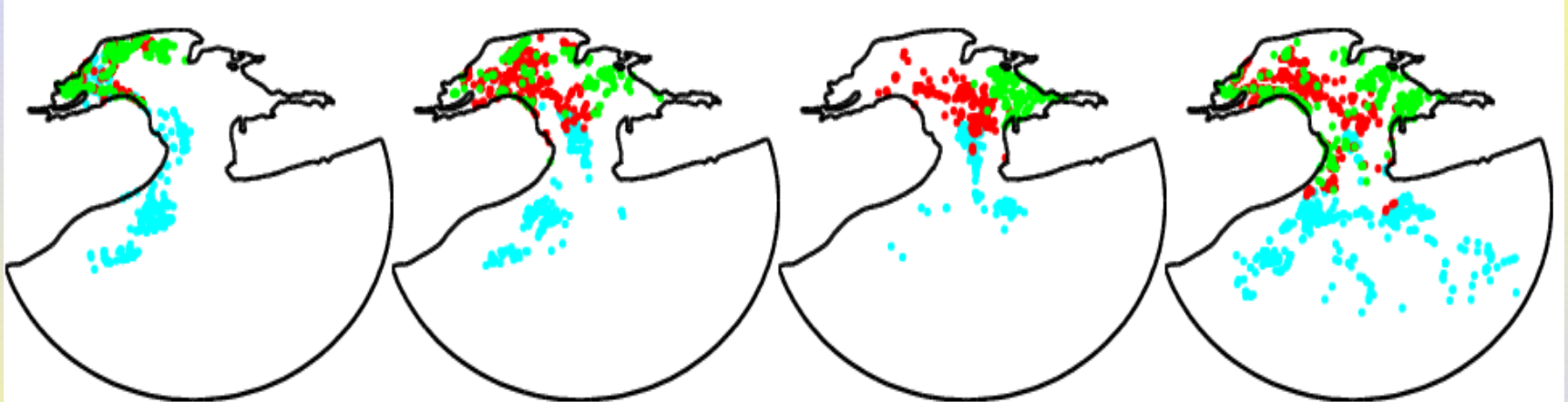
Drogues released at 0.1 m depth at 4 locations in the bay.

On average 100-175 drogues are released at each location.

Sensitivity of Bay-Shelf Exchange to Forcing

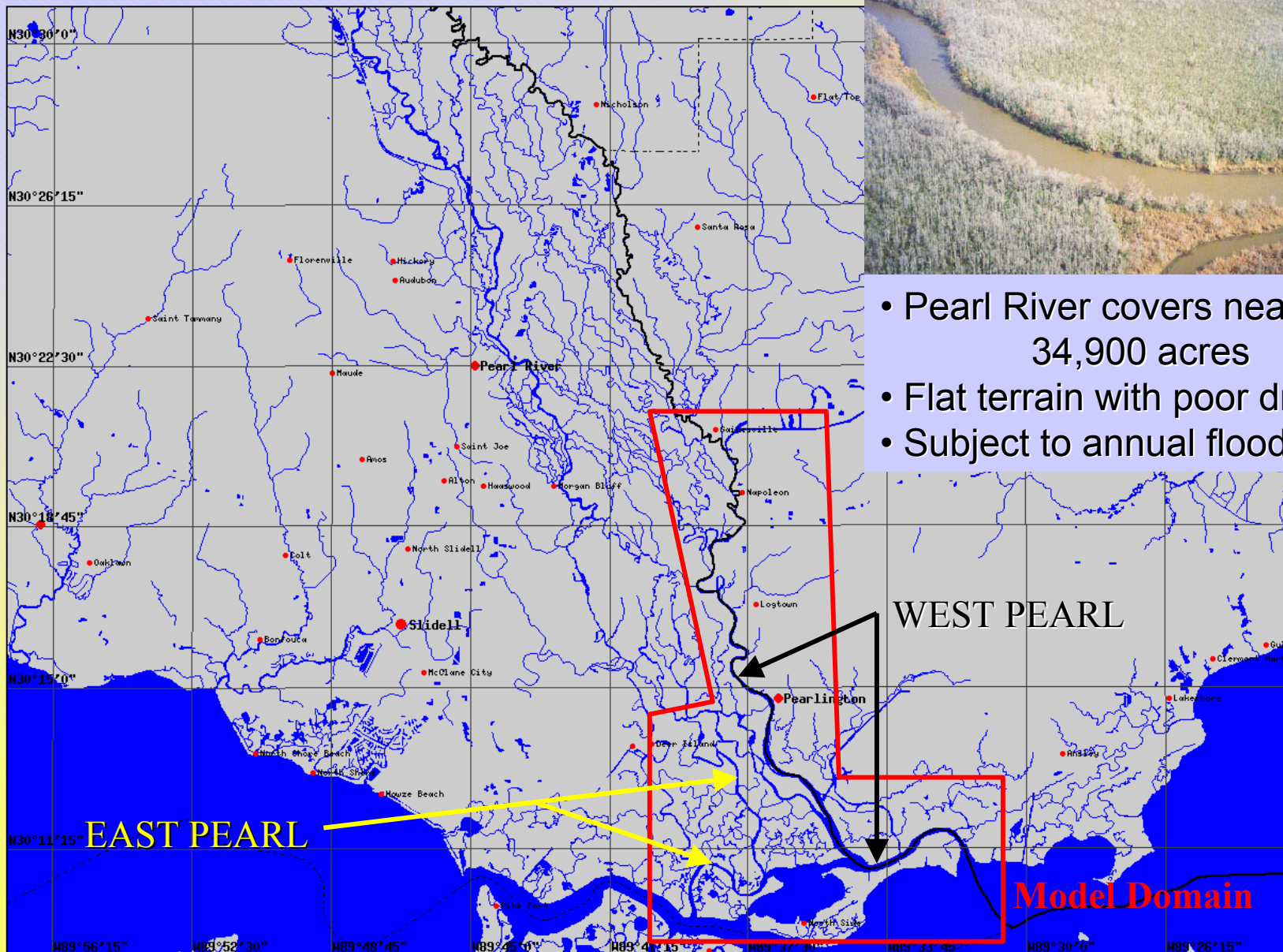
3-D CIRCULATION

After 15 days



2-D CIRCULATION

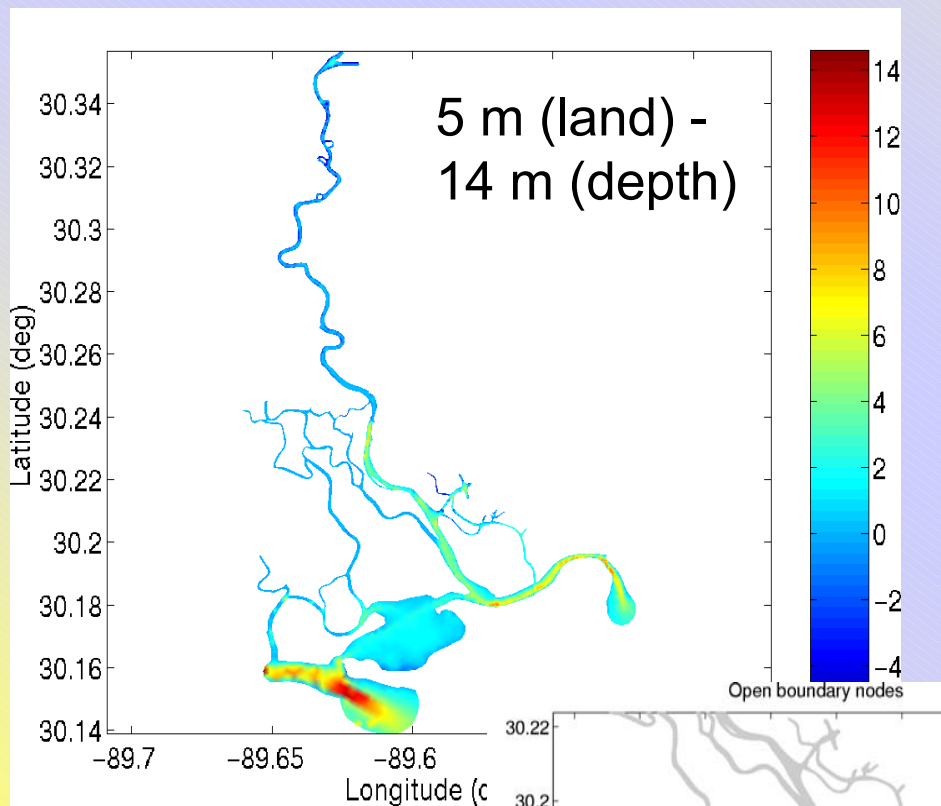
A Model of the Pearl River, MS



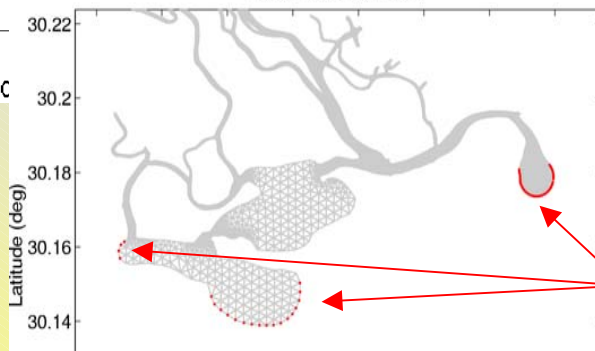
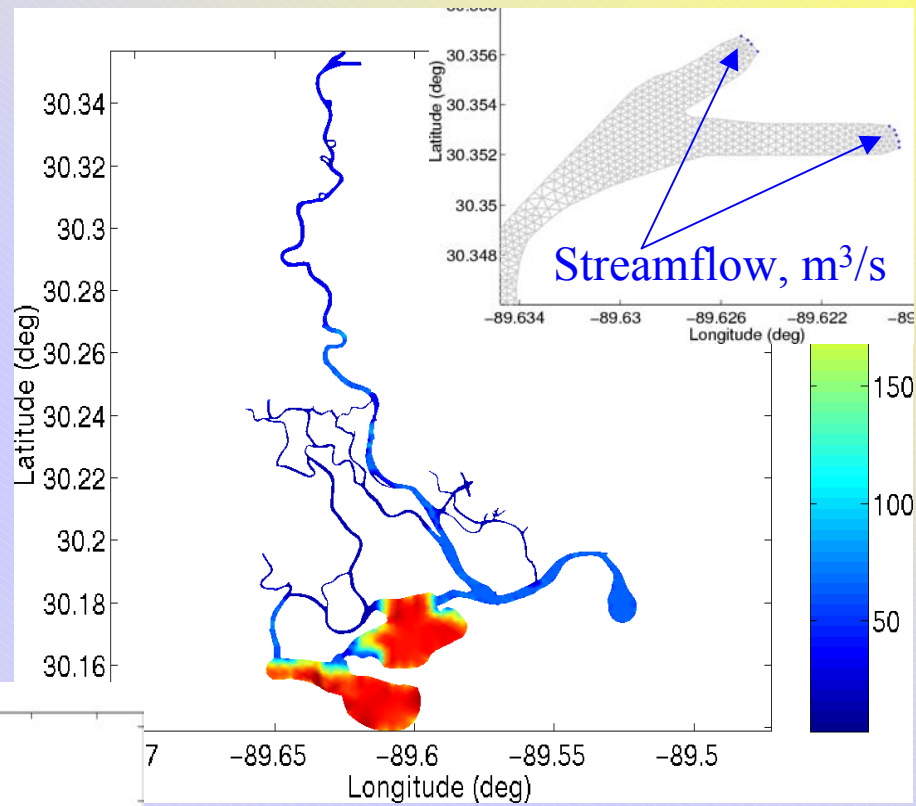
- Pearl River covers nearly 34,900 acres
- Flat terrain with poor drainage
- Subject to annual flooding

A Model of the Pearl River, MS

Bathymetry (m)



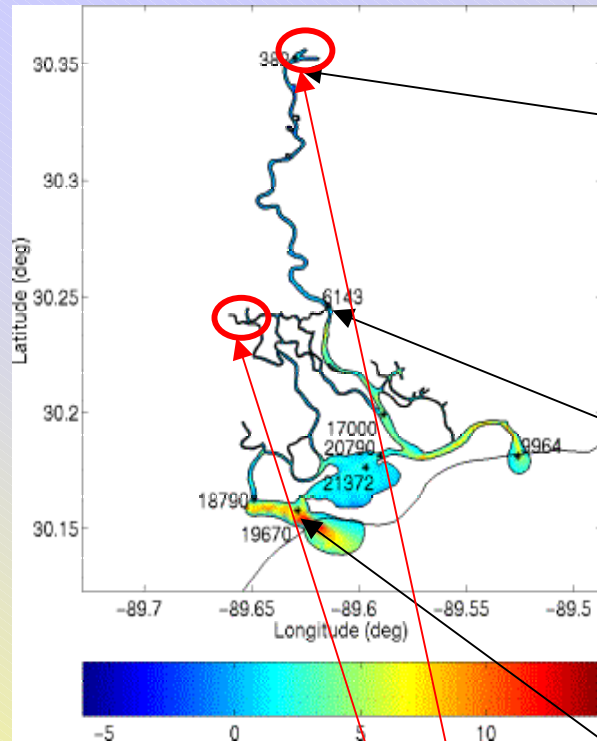
Resolution (m)



Tidal Elevation Forcing
 M_2 , S_2 , K_1 , O_1

Sensitivity of River Flow to Forcing

Currents (u,v) [m/s]



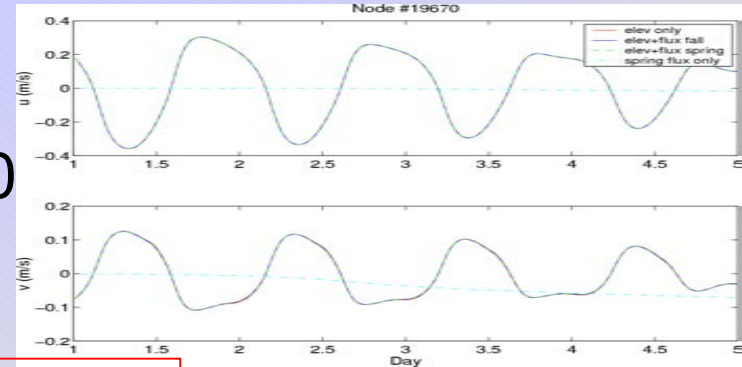
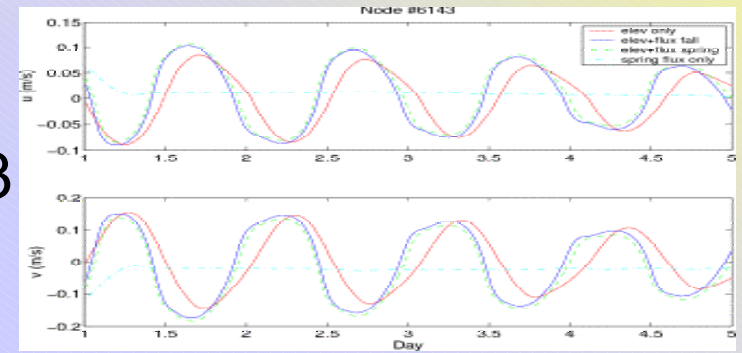
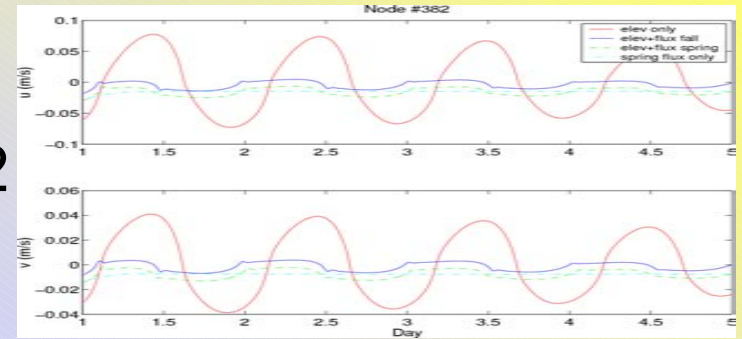
#382

#6143

#19670

- Elevation BCs
- Elevation + Flux – FALL (9 m³/s)
- - - Elevation + Flux – SPRING (47 m³/s)
- . - . Flux Only – SPRING

Hobolochitto (E,W), (34, 5 m³/s)
Pearl River, LA



Sensitivity to Tide and River Forcing

Results

- 3D circulation necessary even in shallow water
- Dependency on forcing event (seasonal, mean, extreme)
- Location and magnitudes of applied river forcing important

Improvements

- Look at variable friction coefficients
- Better forcing
- More nonlinearities

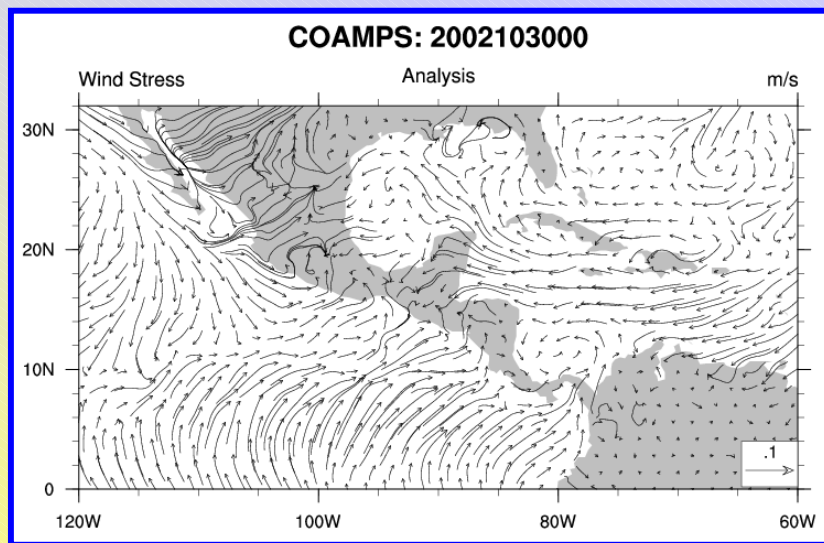
SENSITIVITY TO WIND FORCING

Sensitivity to Wind Forcing

Wind Velocity Sources

Product	Navy COAMPS
Resolution	27 km
Frequency	3 hr

NDBC buoy station 42007
point (30.09N, 88.77W)
1 hr



Wind stresses computed using the formulation of Garratt, (1977):

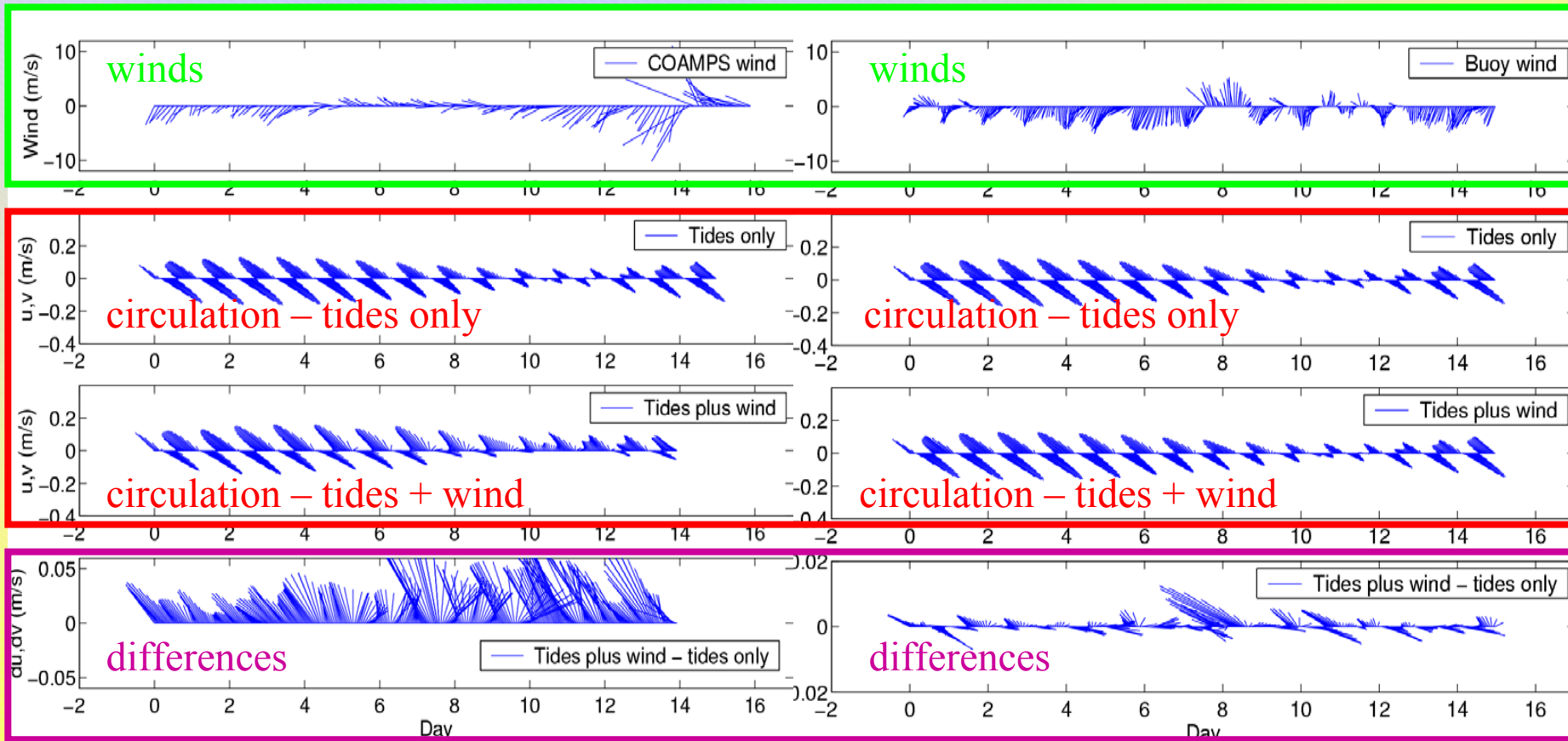
$$\frac{\tau_{\phi,\lambda}}{\rho_o} = C_d \frac{\rho_{air}}{\rho_o} |W| W_{\phi,\lambda}$$

Sensitivity to Wind Forcing

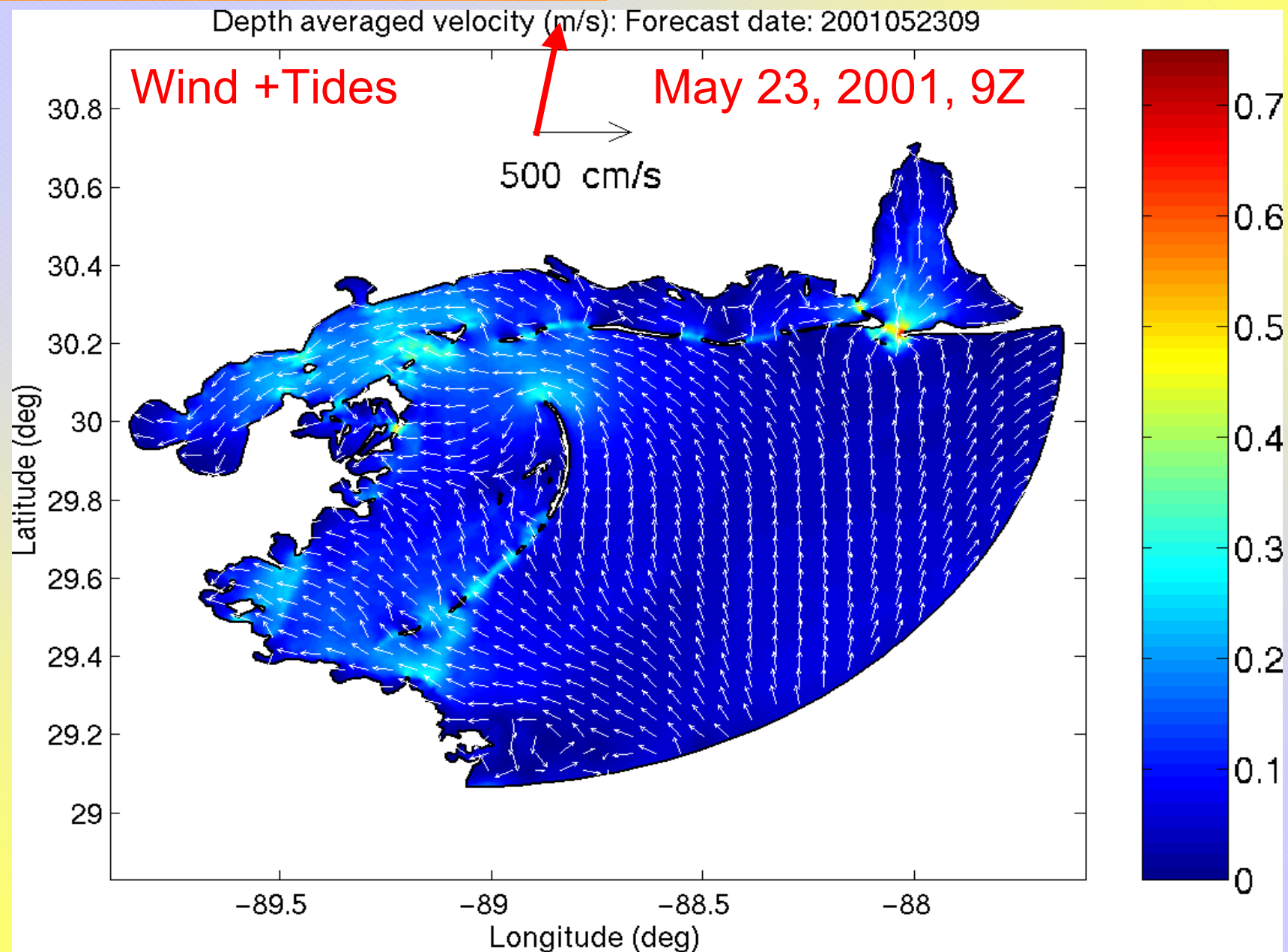
15 day period, May 15-29, 2001

COAMPS

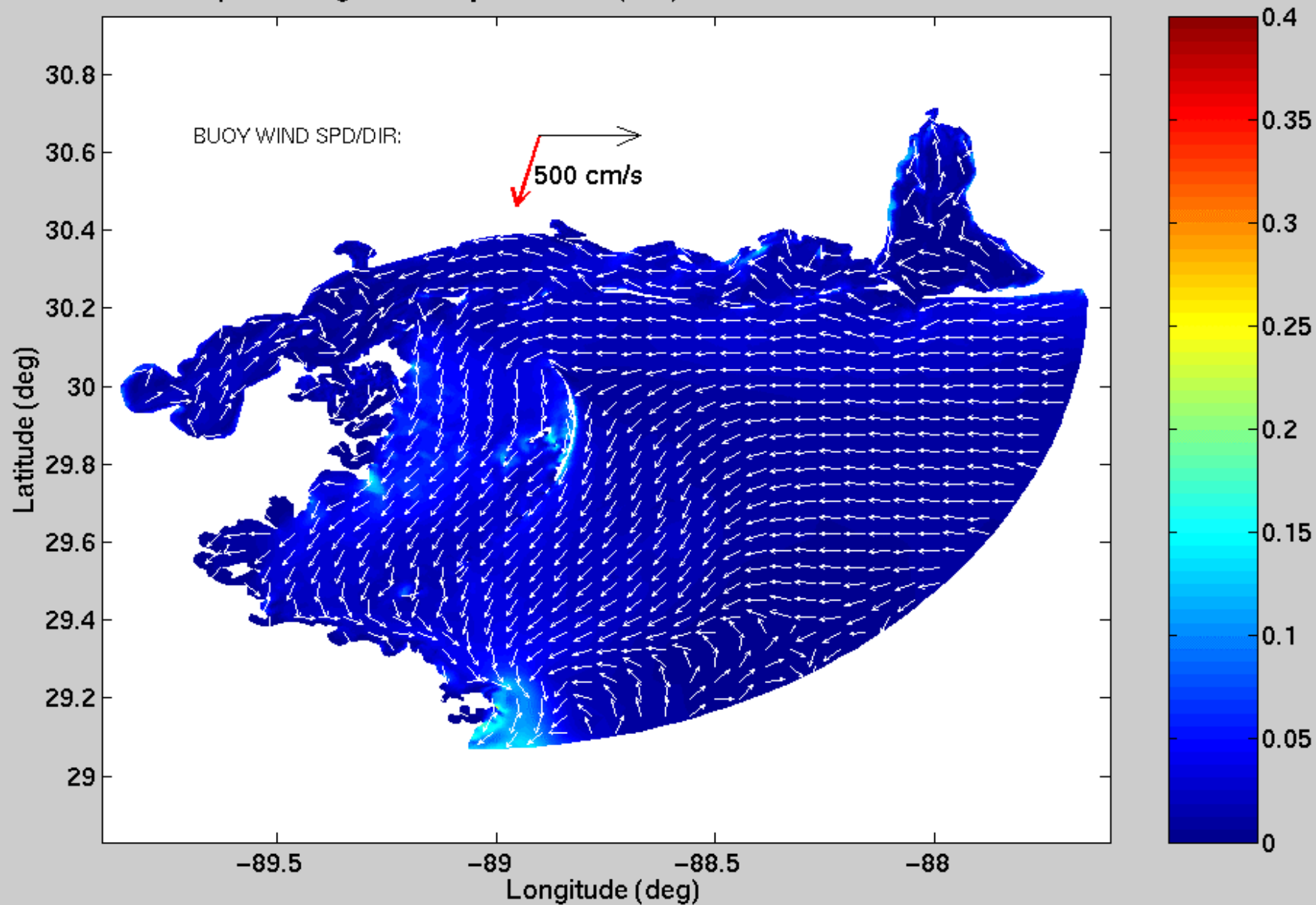
NDBC



Sensitivity to Wind Forcing



Depth averaged velocity difference (m/s): Forecast date: 2001052207



Sensitivity to Wind Forcing

Results

- Winds contribute significantly to the circulation pattern
- Wind effect on circulation very localized (depends on tide)
- Source of winds matters
 - model vs. measured
 - resolution of winds

SENSITIVITY TO OPEN OCEAN FORCING

Open Ocean Forcing – Large Domain Model

EC2001

Tidal Database

Product:

6 tidal constituents

M_2 , S_2 , N_2 , K_1 , O_1 , Q_1

Model information:

Version: ADCIRC 41.11a

2D, wetting and drying

MPI parallelization

Timestep: 5s

Run length: 90 days

Forcing:

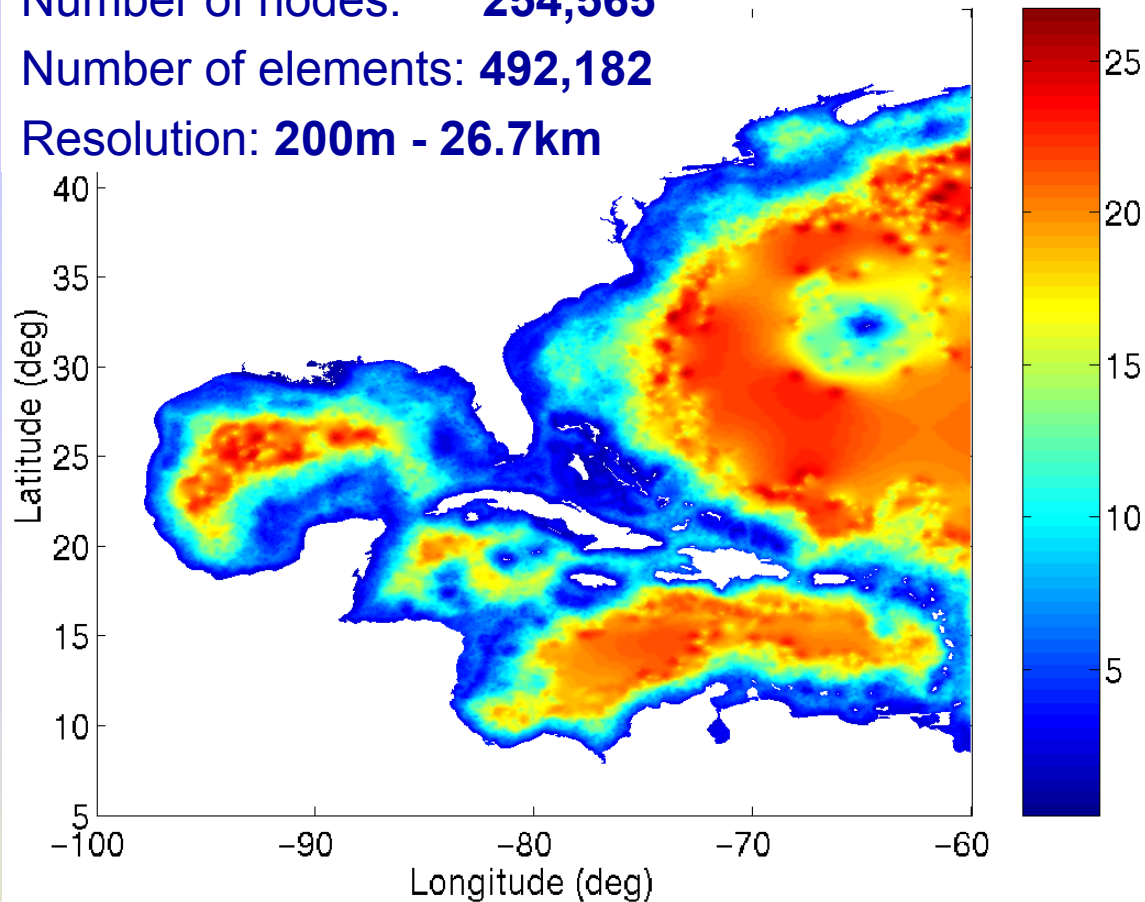
Specified elevation from Grenoble (FES95.2.1)
global database (7 constituents)

Grid Information:

Number of nodes: **254,565**

Number of elements: **492,182**

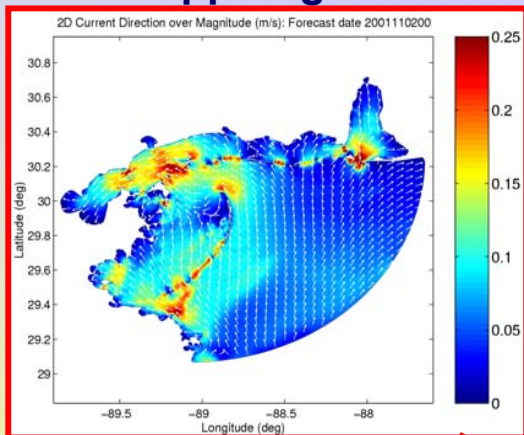
Resolution: **200m - 26.7km**



Sensitivity to Boundary Forcing

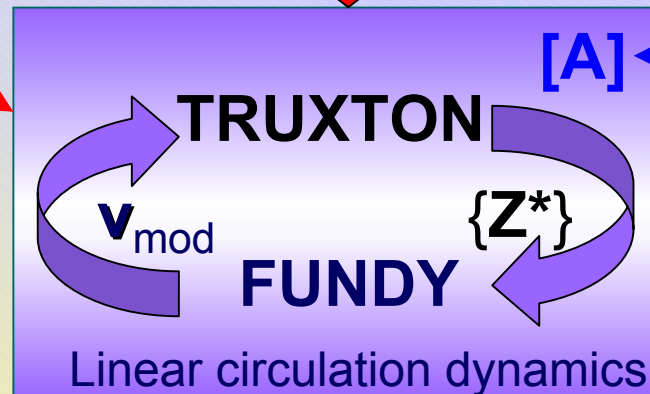
$$\mathbf{e} \equiv \{\mathbf{v}\}_{\text{mod}} - \{\mathbf{v}\}_{\text{obs}} = [\mathbf{A}]\{\mathbf{Z}^*\} - \{\mathbf{v}\}_{\text{obs}}$$

Mississippi Bight Model



THEORETICAL
OBSERVATION
ARRAY, 50x50

$\mathbf{v}_{\text{obs}} (M_2, O_1)$



$[\mathbf{A}]$

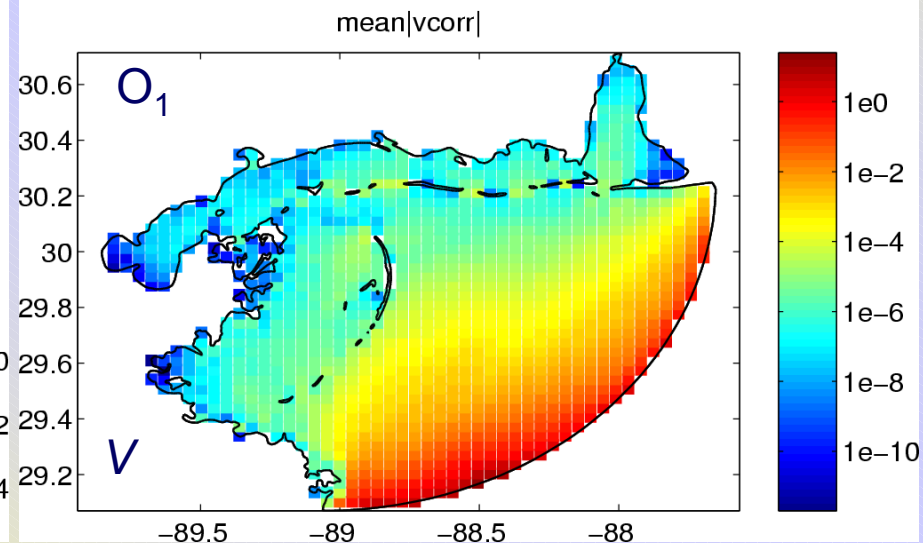
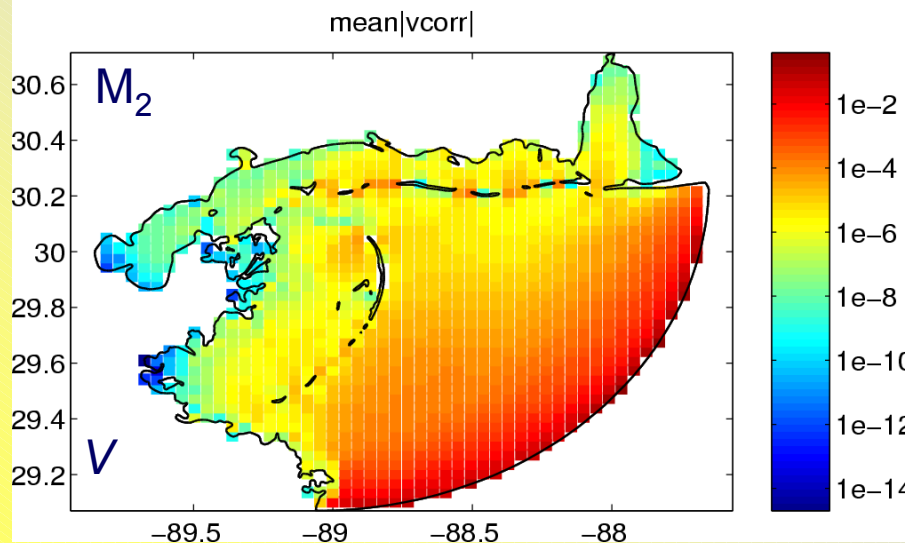
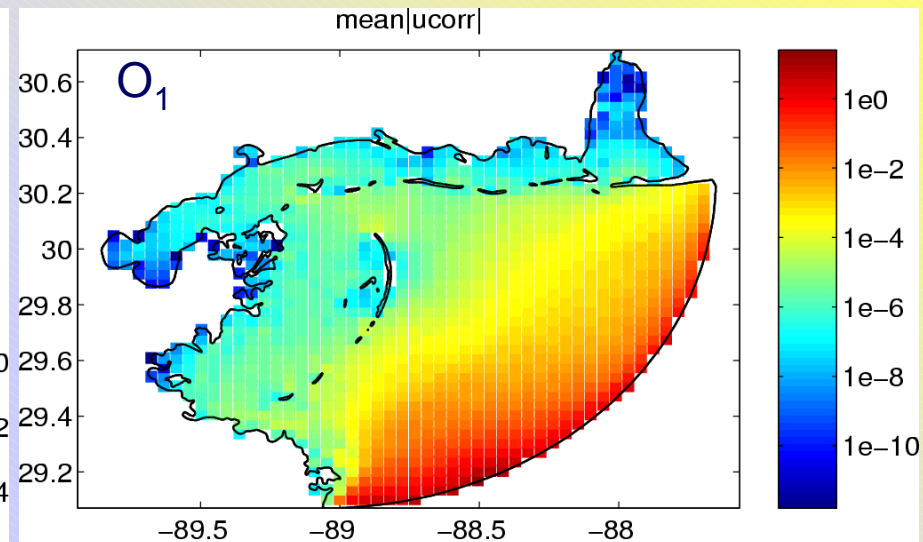
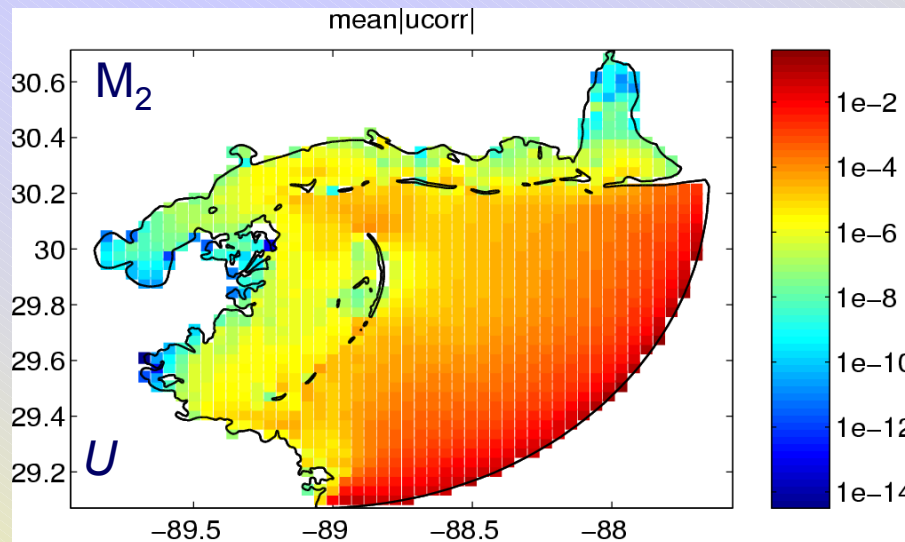
'Correlation' Matrix

Response of velocity
to unit forcing at
each boundary node
for each observation

FUNDY is a linear, barotropic finite element frequency domain model
TRUXTON computes the *direct inverse* of FUNDY

Sensitivity to Boundary Forcing

Mean abs. value of modulus of complex correlations



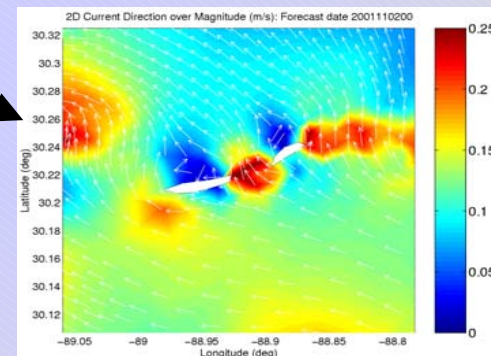
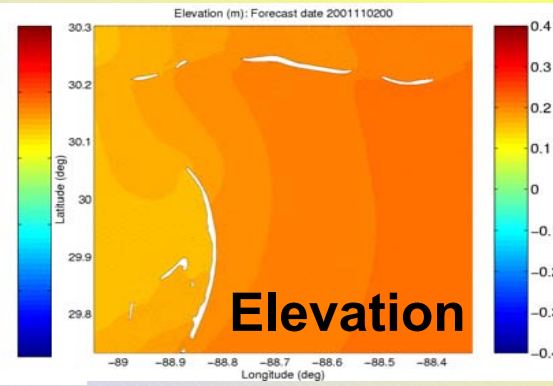
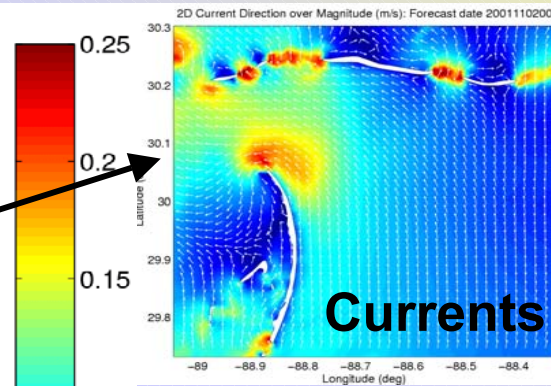
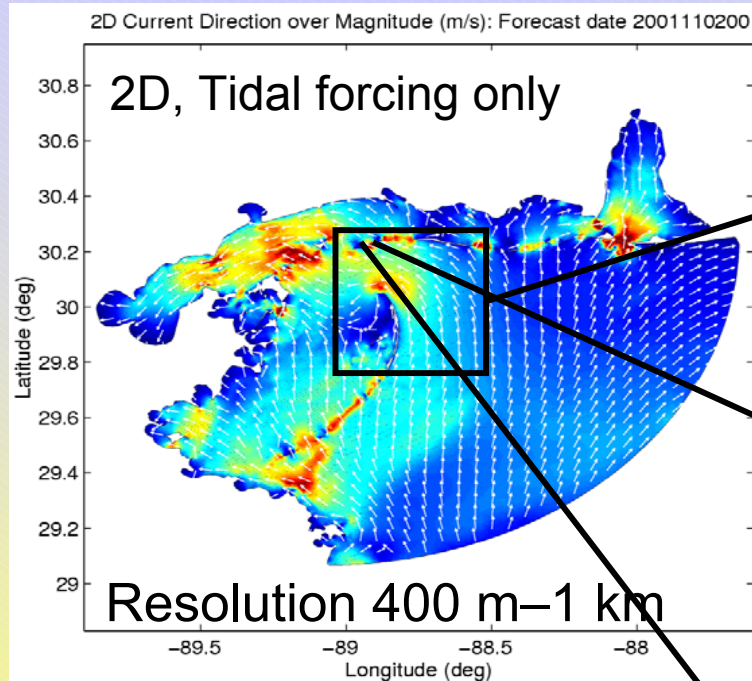
Sensitivity to Open Ocean Forcing

Results

- Propagation of boundary information frequency dependent
- Inverse model 'correlation' matrix an excellent tool for examining the influence of boundary values/location

AUVFEST 2001 – Prototype System

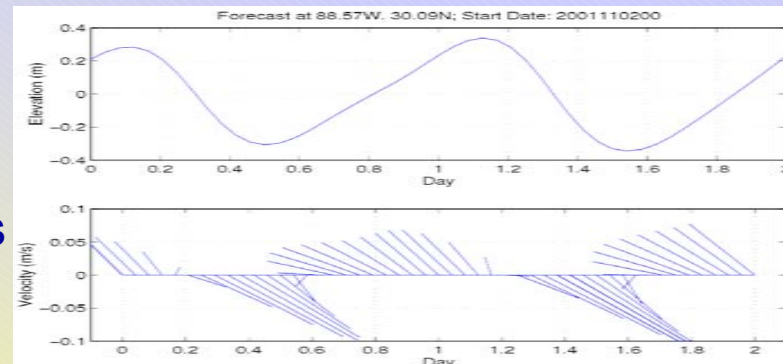
Barrier Islands



Ship Island

48 hour forecasts

- 3 hour snapshots of
 - elevation
 - current magnitude and direction
- time series of elevation and currents at 2 stations



Elevation

Currents

Development of a Forecast Capability for Coastal Embayments of the Mississippi Sound

Purpose of Sensitivity Studies

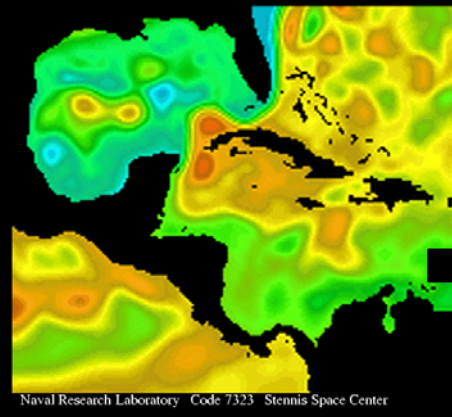
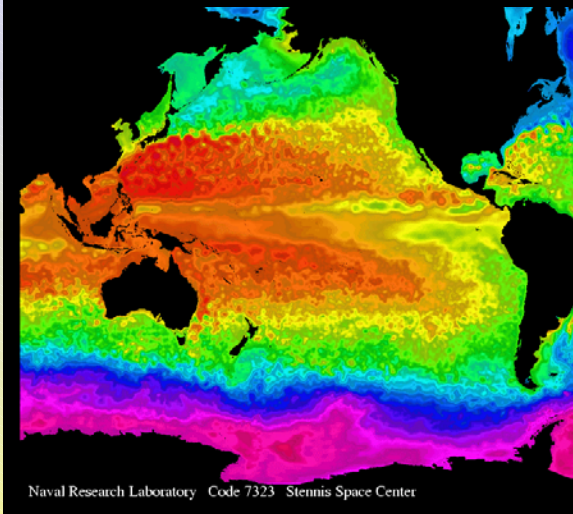
- achieve relocatability
- determine required accuracy of forcing
- assess modeled dynamics

Future of the Forecast System

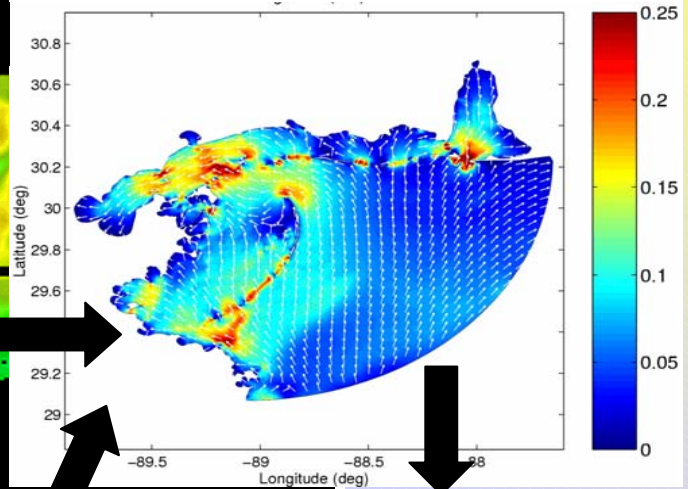
- Combine embayment models into seamless representation of the near-coastal waters
- Focus on river dynamics and shoreline inundation
- Advance real-time prediction to include all relevant forcing
- Pursue model coupling at offshore boundary

Open Ocean Forcing – Model Nesting

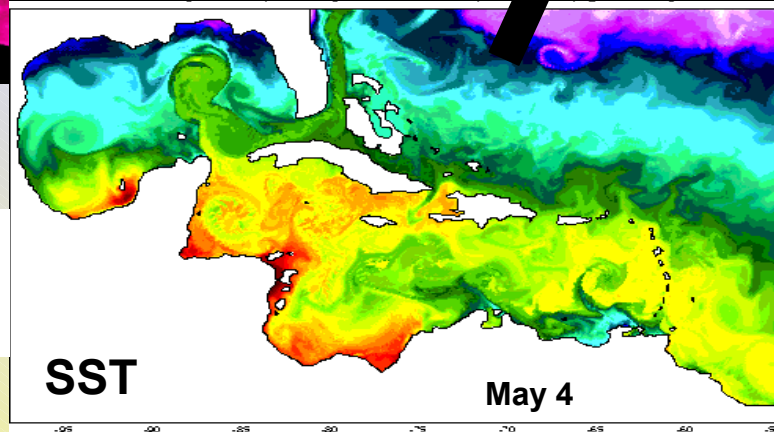
**NCOM 0.125°
Global and Gulf of Mexico**



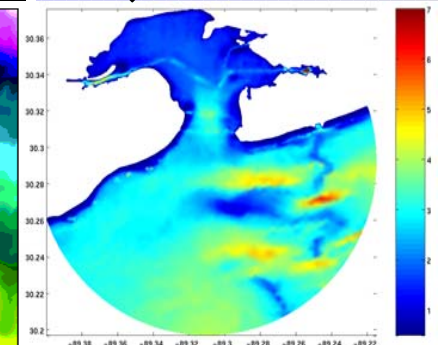
**ADCIRC 1 km
MS Bight**



**HYCOM 0.08°
Intra-Americas Sea**



**ADCIRC 100 m
Bay St. Louis, MS**

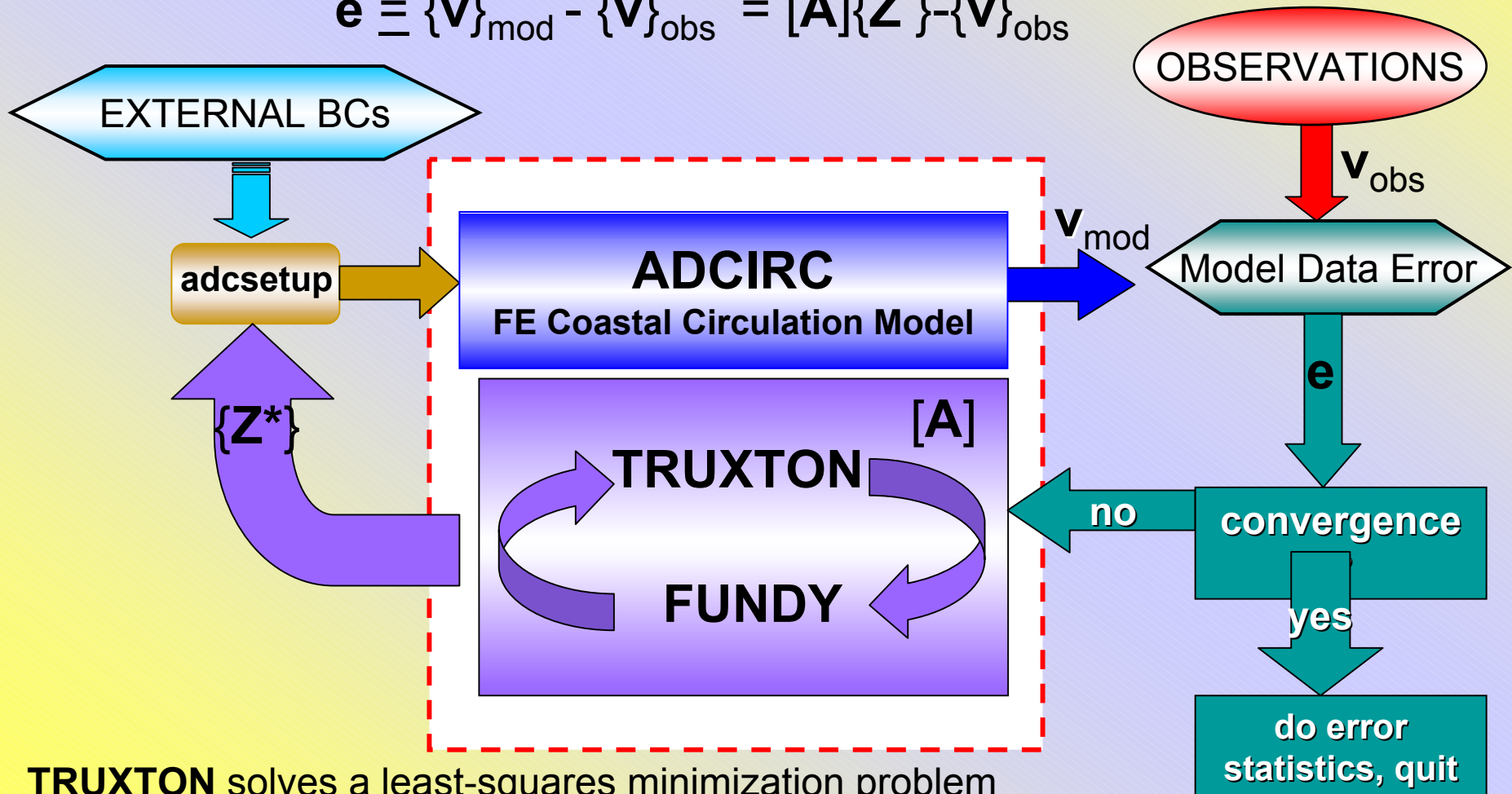


Incremental Data Assimilation

FUNDY is a linear, barotropic finite element frequency domain model

TRUXTON computes the *direct inverse* of FUNDY

$$\mathbf{e} \equiv \{\mathbf{v}\}_{\text{mod}} - \{\mathbf{v}\}_{\text{obs}} = [\mathbf{A}]\{\mathbf{Z}^*\} - \{\mathbf{v}\}_{\text{obs}}$$



TRUXTON solves a least-squares minimization problem

Automated Script Infrastructure

